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Data for Designers

We are convinced from conversations in trains, clubs and similar places that the propaganda made by the plastics industry has been successful. Not only are people interested in what has been told them by way of advertisements, Press articles and scientific literature, but are of themselves inventing outlets for its application on their own initiative. Thus, the situation does resemble, as Mr. Gloag points out in his book, "The Missing Technician," the beginning of the 18th century, when cast iron sought to establish itself. At that time, Wilkinson and his contemporaries created markets for cast-iron products which have been retained until to-day. It should, however, be recorded that his enthusiasm for cast iron, backed up as it was by clever propaganda and an abundance of finance, failed to oust timber from uses where no lasting benefits could be shown. A typical example is the manufacture of coffins. We suggest that there will be quite a number of "coffins" ultimately to be found among the lines of manufacture now being proposed as suitable for making in plastics.

The field for castings is not narrow. Take, for instance, the weight factor; here the industry can supply castings ranging from magnesium to lead. Next comes shape, including dimensional accuracy, and in this field, surely, the founder is supreme and is still well in advance of the plastics industry. For articles requiring mechanical strength in its various aspects—tensile, compression, shock and vibration resistance, and fatigue endurance—the range available is not merely wide, but distinctly impressive. Moreover, enlightened research is constantly extending the boundaries, as witness, in the case of cast iron, the threefold increase in tensile strength within three decades. In recent years, much more attention has been paid to machinability, and here again the product of the foundry compares favourably with that from the forge or rolling mill, and the sole bugbear—internal flaws—is rapidly being swept away by improved technique. Modern fashion commendably insists on a pleasing surface finish, and this is bound up with hygiene, atmospheric and chemical resisting properties.

In this direction, the industry is particularly well situated, because not only are a number of alloys, such as gunmetal and cast iron, inherently so constituted as to resist many forms of attack, but the range of coatings nowadays applied can meet the most exacting specifications. For colour, there are paints, stove enamels, vitreous enamel and anodising, to mention only the more important ones. Of these, vitreous enamel has had the widest application, and is well worthy of increased attention by every section of the cast-iron industry. The objectives of this attention should be the production of data designed to interest the engineering designer, the industrial designer, and the architect. Among the first questions posed by the designer will obviously be the range of thicknesses capable of being vitreous enamelled; then he will require information as to the radii of corners; the effect of processing on the mechanical properties, especially warping; the ability to bolt a processed component on to a second, and so forth.

Cast products show such a wide range of properties that to-day it is difficult to envisage where, provided that the fullest information is readily available to the designer, that a good case for their use could not be established, especially in the markets selected as suitable for exploitation by plastics. For instance, finger plates protecting electric-light wall switches are attached by means of a hollow threaded plastic component. Personal experience has shown the life of the thread is short and that a die casting suggests itself as being capable of giving better service. Properly marshalled, facts as to the potentialities of castings would ensure prosperity for the foundry industry for many years beyond the immediate post-war era.

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FUTURE OF MAGNESIUM CASTINGS

SPECULATION ABOUT POST-WAR PRICES

Dr. D. Basch, Consultant on Materials and Processes, General Electric Company, Schenectady, N.Y., in a Paper which he presented to the Philadelphia Chapter of the American Foundrymen's Association has summarised the post-war possibilities of magnesium castings in the following paragraphs:—

Magnesium alloy ingots of "A" purity now cost about 20 to 21 cents per lb., aluminium alloy ingots about 15 cents per lb. Considering the weight ratio, the prices of aluminium and magnesium alloy ingots are kept in balance.

There is a great deal of speculation about post-war prices. Of course, no one knows exactly what will happen, but there seems to be a general feeling among metal producers, etc., that, after the war, the price of primary aluminium ingot will be around 10 cents per lb., a secondary aluminium around 6 cents per lb., primary magnesium around 15 cents per lb., and secondary magnesium around 10 or 11 cents per lb. The ratio of these prices is fairly close.

If these figures are correct (and it is emphasised that so far they are only guesses), following again the weight ratio and competing with primary magnesium, brass ingot would have to sell for about 5 cents per lb., cast-iron pigs about 4 cents per lb. Competing against secondary aluminium, which is being used in ever-increasing quantities in the foundry, brass ingot would have to sell for about 2 cents per lb. and pig-iron for about 2.3 cents per lb. The actual casting cost, of course, will be affected by other factors apart from the basic metal cost.

Forecast of Developments

Some of the new developments that may be forecast in the field of magnesium alloys are:—

(1) New alloy compositions to shorten the solidification range, to reduce danger of microporosity.

(2) New alloy compositions to yield high physical properties without high temperature heat treatment.

(3) Improved corrosion resistance of magnesium alloys, especially against salt water and tropical humidity.

(4) Improved protective coatings for magnesium.

(5) Improved die-casting technique and alloy compositions for pressure die castings to make possible high temperature heat treatment with corresponding properties. (Improved structure and density).

(6) Development of fluxes which are less destructive on steelwork in magnesium plants.

(7) Adaptation of magnesium alloys to plaster moulding process as now used for brass and aluminium.

(8) Tightening of precautions and handling routines in castings and machine shops to eliminate unnecessary fires and explosions which prejudice users against magnesium.

(9) Development of bearing and sliding wear properties of magnesium alloys.

SAVE PAPER WHEN YOU CAN

INSTITUTE CALENDAR

MEETINGS FOR APRIL 1944

Lancashire Branch.—Annual general meeting. "The Laboratory and the Foundry," by D. Fleming. At the Engineers' Club, Albert Square, Manchester, on April 1, at 3 p.m.

Lincoln Section.—Annual general meeting. Short Papers. At the Technical College, Lincoln, on April 1, at 3 p.m.

West Riding of Yorkshire Branch.—"General Foundry Practice," by W. Peacock. "Patternmaking," by R. L. Simpson. At the Technical College, Bradford, on April 1, at 6.30 p.m.

Sheffield Branch.—"Some Ground Work on a Flying Casting," by M. Brown. At the Royal Victoria Hotel, Sheffield, on April 14, at 7 p.m.

Birmingham Branch.—"An Introduction to Spectrographic Analysis," by Dr. A. G. G. Leonard. At the James Watt Institute, Great Charles Street, Birmingham, on April 28, at 7.30 p.m.

West Riding of Yorkshire Branch.—Annual general meeting. At the Technical College, Bradford, on April 29, at 6.30 p.m.

IRON AND STEEL INSTITUTE

The Council of the Iron and Steel Institute have awarded the Bessemer Gold Medal for 1944 to Mr. Essington Lewis, C.H., Director-General of Munitions and Director-General of Aircraft Production for Australia, formerly of the Broken Hill Proprietary Company, Limited, in recognition of his outstanding services to the iron and steel industry of Australia. Mr. Lewis started his business career with the Broken Hill Pty. Company, and is now chief general manager. He is also managing director of Australian Iron & Steel, Limited, and on the boards of various other companies, including Rylands Bros. (Aust.) Pty. Limited, Lysaghts Newcastle Works Pty., Limited, and Stewarts and Lloyds (Aust.) Pty., Limited.

Lieut.-Col. Sir John Greenly has accepted an invitation to become an honorary vice-president of the Iron and Steel Institute. Sir John Greenly was until recently president of the Institute of Metals.

AMERICAN STEELFOUNDERS' ENTERPRISE

A practical demonstration of foundry methods, from blueprints to finished casting, was devised recently by members of the Eastern Division of the Steel Founders' Society of America and set up, together with a melting furnace in full operation, in the Hall of Prime Movers at the Franklin Institute, Philadelphia. Sample castings are poured at relatively low temperatures from the Ajax-Tama-Wyatt electric induction type furnace, and the various ways of applying gates and risers, as well as proper mould and core handling for steel and iron, are illustrated by representative castings, both finished and in the rough. Modern tool set-ups for machining iron, steel and malleable castings are also explained.

SLIP COATED SYNTHETIC FOUNDRY SAND

A Ceramist's views on foundry sand problems

By FELIX SINGER, Dr.-Ing., Dr.phil., M.I.Chem.E.,
Consulting Ceramist

(*Concluded from page* 264)

The German experimenters[14] testing two types of sand-mixing machines found them unsatisfactory, but the data they publish are too scanty to allow an estimate of what actually happened in their experiments.

The Moulding Materials Sub-Committee[15] found by microscopic examination of a mixture of transparent Chelford sand, limonite-incrusted South Cave sand, 3 per cent. bentonite and water, that the limonite is equally distributed over the whole sand surface after four minutes milling in a pan-mill. This proves, in the author's opinion, no more than the fact that limonite, which is not a clay, is particularly easy to distribute, probably because of its extremely small particle size.

Even if finely powdered dry clay is carefully mixed with the sand before the tempering water is added, no substantial coating effect can be expected, for the reasons given above, before the water has converted each of the little lumps of dry, brittle clay into wet, adhesive and tough lumps of films of plastic clay, and until the phenomenon sketched in Figs. 2 to 4 has progressed sufficiently in the course of further mixing. Therefore, the usual mixing operation, however performed, must always involve clay in its plastic state before it can become effective.

This does not mean that the bulk addition of clay in the wet, plastic state would offer any advantages. On the contrary, the cheap pre-disintegration of the dry brittle clay, if insufficient by itself, helps to reduce the duration of the plastic mixing stage. Furthermore, large lumps of plastic clay are liable to clog pan-mills and certain other types of mixers.

There is, however, a third known state of the clay, in which the colloidal cohesion of the individual clay particles is greatly reduced, with the result that mixing and coating work are greatly facilitated: the state of a slurry, which Mooney[16] has employed to effect the rebonding of synthetic sand.

The main difficulties in the use of slurries is the excessive amount of water required to prepare the liquid clay suspension. The excess of water must either be evaporated subsequently or absorbed by the dry clay coating already covering the sand particles of reclaimed sand. Unless the finished product embodies the clay-to-water ratio which yields tough, plastic clay, the strength of the bonded sand will be quite insufficient. In other words, the reduced cohesion between the clay particles is highly desirable during the mixing operation, but strong cohesion is required once the coating of the sand particles has been effected.

As a clay worker, the author is obviously familiar with the art of "liquefying" clay with the aid of modest proportions of water and with additions of minute quantities of electrolytes (deflocculants). These "slips," despite their perfectly liquid, cream-like consistency, generally do not contain more water than plastic clay to which such deflocculants had not been added, and the process of deflocculation can easily be reversed by additions of similarly minute proportions of other electrolytes ("flocculants").

It would appear that the addition of suitable amounts of deflocculants added to the mixer containing sand, clay and tempering water would result, after a very short mixing period, in a slip-bonded sand in which the colloidal clay slip would cover the sand surface completely. Toughness could thereafter be re-imparted to the perfectly distributed clay by an addition of a flocculant, so as to produce a particularly high green strength. If a high dry strength were sought, the subsequent flocculation could be omitted.

To test this idea, the author used an English clay which yielded a perfect, creamy and stable slip on addition of 42.5 per cent. of tap water, 0.39 per cent. of ammonium oxalate and 0.1 per cent. of sodium silicate (syrup), calculated on a dry clay basis. The sand used was a graded silica sand as described above.

As a control test, the sand was mixed with 10 per cent. of its weight of dry, powdered clay and 3½ per cent. tempering water in a laboratory Beken mixer. It was tested for green strength by the A.F.A. method, and mixing and testing were continued until the green strength remained constant, indicating that the maximum spread of the clay bond over the sand surface had been reached. Then more water was added, mixed and tested again, etc., and the "normal" values were obtained for green strength at different moisture contents.

In a second experiment a mixture of 10 per cent. clay, 4.5 per cent. water and, as deflocculants, 0.05 per cent. ammonium oxalate and 0.01 per cent. sodium silicate (calculated as dry $Na_2O_3.SiO_2$) was used. The maximum value of the green strength was attained almost at once, which shows that the spreading of the slip over the sand surface is extremely easy. As expected, the green strength values—2.4 and 3.4 lb. per sq. in. for three and for 10 blows of the rammer—were extremely low. It was also noted that the mixture was very wet to the touch, much wetter than the "normal" (raw clay) mixture at the same water content.

Then was added, as a flocculant, 0.5 per cent. powdery hydrated lime mixed with 0.35 per cent. water. The effect was most striking. The sand mixture became warm, very dry to the touch, and the green

Slip Coated Synthetic Foundry Sand

strength leapt to very high values. Gradual additions of more water reduced this high strength only moderately, and the mixture containing 7.35 per cent. water was very similar in strength and apparent wetness to the "normal" mixture containing only 3.5 per cent. water.

The numerical results of these deflocculating and flocculating experiments carried out with different water contents are given in Table I and illustrated in Fig. 6.

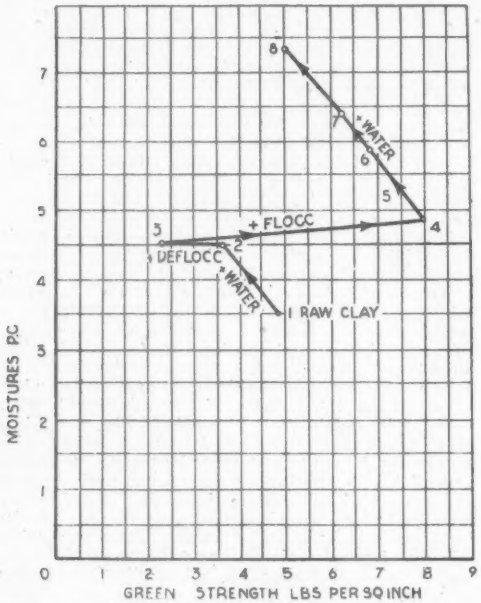

FIG. 6.—RESULTS OBTAINED IN FLOCCULATION AND DEFLOCCULATION TESTS.

The considerable increase in green strength on addition of the flocculant, which amounts to 66 per cent. above the highest value obtained with the control mixture, leads the author to the presumption that the

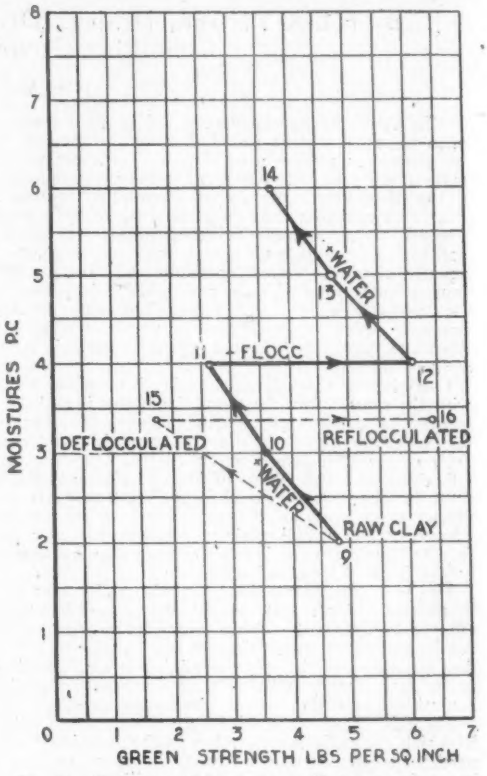

FIG. 7.—RESULTS OBTAINED IN FLOCCULATION AND DEFLOCCULATION TESTS.

TABLE I.—*Sand, 10 per cent. Clay, Tempering Water.*

No.	Moisture, per cent.	Green strength, lb. per sq. in.		Feel.	
		3 Blows.	10 blows.		
1	3.5	4.8	7.5	Moderately moist ..	"Normal" mixture.
2	4.5	3.7	5.7	Moderately moist ..	
3	4.5	2.4	3.4	Very moist	Deflocculated.
4	4.85	8.0	10.4	Very dry	Flocculated.
5	5.35	7.2	10.2	Dry	
6	5.85	6.9	9.0	Moderately dry	
7	6.35	6.3	8.7	Slightly moist	
8	7.35	5.0	7.1	Moderately moist	

raw clay must be in an intermediate state of flocculation. To test this the same sand was used with 6.66 per cent. clay and 2 per cent. water mixed until the maximum green strength was obtained, and then more water was added in small portions and the decrease in green strength was observed as the proportion of water increased. There after 0.33 per cent. powdery hydrated lime was mixed again, and the green strength was found to be more than doubled (Table II and Fig. 7).

As a counterpart to this experiment, the slip experiment was repeated using 6.66 per cent. clay, 3.36 per cent. water, 0.078 per cent. ammonium oxalate, and 0.015 per cent. sodium silicate (calculated as dry $Na_2O_3.SiO_2$). The result was a very low green strength, which was raised to a very high figure by an addition of 0.2 per cent. lime. The numerical results of this experiment are given in Table III, and are also shown in Fig. 7.

It will be noted that the sequences of deflocculation followed by flocculation resulted in rather higher green strength values than the mere addition of flocculant to a "normal" raw clay mix. This is ascribed to a better spreading of the clay over the surface of the sand particles in the perfectly deflocculated state.

The author has also made a preliminary study of the influence of flocculants and deflocculants on the dry strength of artificially bonded moulding sand, using 1-in. by 1-in. test cylinders in a little steel mould. They were rammed with three blows of the A.F.A. rammer, dried at only 105 deg. C. for four hours, and crushed by means of the B.C.U.R.A. spring balance.

By experiment it was found that the green strength of the small test cylinders, rammed with three blows of the rammer, in lbs. per sq. in., was the same as that of A.F.A. cylinders rammed with five blows. In a number of cases, therefore, the green strength to dry strength ratio can be given. The low drying tem-

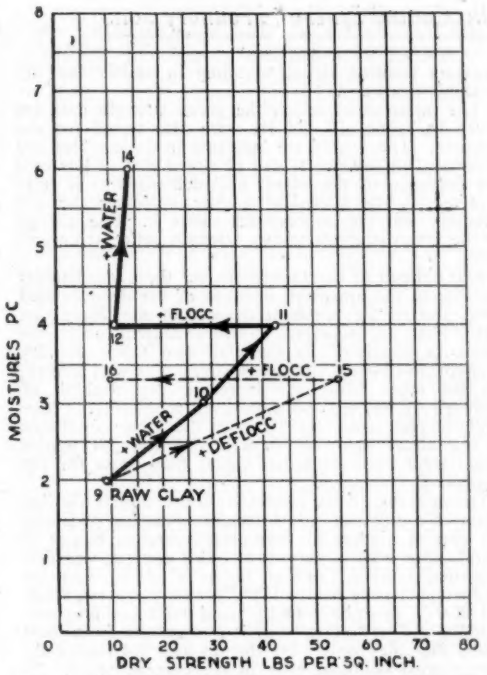

FIG. 8.—RESULTS OBTAINED IN FLOCCULATION AND DEFLOCCULATION TESTS.

TABLE II.—*Sand, 6.66 per cent. Clay, Tempering Water.*

No.	Moisture, per cent.	Green Strength, lb. per sq. in.		Dry Strength, lb. per sq. in.	Ratio, green to dry Strength.	Feel.	
		3 Blows.	10 Blows.				
9	2.0	4.8	6.4	8.5	1.22	Very dry	
10	3.0	3.6	4.75	27.7	0.262	Moderately moist ..	"Normal" mixture.
11	4.0	2.7	3.5	42.5	0.114	Very moist	
12	4.0	6.1	7.35	11.0	1.04	Very dry	
13	5.0	4.75	6.4	—	—	Moderately dry	Flocculated.
14	6.0	3.75	5.0	14.0	0.472	Moderately moist	

TABLE III.—*Sand, 6.66 per cent. Clay, Tempering Water.*

No.	Moisture, per cent.	Green Strength, lb. per sq. in.		Dry Strength, lb. per sq. in.	Ratio Green to dry Strength.	Feel.	
		3 Blows.	10 Blows.				
15	3.36	1.76	2.33	55.0	0.06	Moist	Deflocculated.
16	3.36	6.4	9.0	11.0	2.42	Dry	Flocculated.

perature resulted almost certainly in unduly low dry strength figures.

The mixtures of which the green strength data are given in Tables II and III were also tested for dry strength. The results are indicated in these tables and illustrated in Fig. 8. It will be noted that in this case the influence of flocculants and deflocculants is fully reversed. The flocculant greatly decreases the dry strength, and the deflocculant raises it. The change in the green strength to dry strength ratio is remarkable.

It is difficult to say to what extent these peculiarities are due to the apparent moisture of the deflocculated bond and to the apparent dryness of the flocculated one. That an increased moisture content which reduces the toughness of the clay also raises the dry strength and lowers the green strength is well known. On the other hand, the increased dry strength of sodium clay has also been observed repeatedly.[17] Bentonite-bonded sand, tested under the same conditions as the above samples, showed dry strength figures which were not very much higher than those for the English clay samples.

The principle of the method to use colloidal alkaline liquid clay slips not only for ceramic casting purposes, but also as binders for non-plastic ceramic bodies in a stiff state with a very low water content was first published in 1908,[18] but, as far as is known, was not used commercially before 1925.[19] [20] Furthermore, Slack and Rees[21] describe foundry sand mixtures prepared with the aid of "slips," but it is apparent from their results that they only used slurries and not real, fully deflocculated colloidal slips in the ceramic sense.

In the above experiments only one type of clay was tested, and only one set of flocculants and deflocculants used, so it can safely be assumed that the figures are not optimum values. Other clays, other deflocculants and flocculants may be much better suited to the requirements of the actual foundry practice, and might have to be adapted to different local conditions.

Conclusions

The following facts appear, however, to be established.

(1) The conversion of the clay bond into a true colloidal "casting slip" (in the ceramic sense) permits the complete covering of each particle of sand with a thin layer of clay within a very short mixing period and without introducing an excess of water.[22]

(2) Owing to the fluidity and low cohesion of the liquefied clay, the sand thus bonded can easily be rammed to give very high dry strength figures approaching those obtained with bentonite-bonded sand; but the green strength figures are rather low, as could be expected from the lack of cohesion between the deflocculated clay particles.

(3) If the deflocculated clay coating is subsequently reflocculated, the green strength rises to very high values, substantially above those obtained with raw clay by prolonged mixing. The dry strength figures are, however, very much lowered.

(4) An addition of flocculants to sand bonded with raw clay also raises the green strength. The various raw clays are obviously in varying intermediate states of flocculation and can probably be made more suitable for their purpose by additional flocculation or deflocculation, as the case may be. The adaptability and usefulness of domestic bond clays and even of naturally bonded sands could be considerably extended thereby.

(5) The deflocculation, the reflocculation and the mixing in general are best carried out in a specialised non-crushing mixing machine of the type.

Acknowledgments

The author wishes to acknowledge with sincere gratitude the help he has received in the preparation from Lavino (London), Limited (for the provision of testing apparatus and permission to publish the results); Moler Products, Limited (for laboratory facilities); and from Dr. L. Blass (for assistance in carrying out the experimental work and many useful suggestions).

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AN INTERESTING PRESENTATION

Five employees of Stewart & Gray, Limited, of Paisley Works, Swains Road, Tooting Junction, London, S.W.17, Mr. George Lefever, Mr. Chris Pittard, Mr. Joe Agland, Mr. Will Hawes and Mr. Harry Woods, having completed 21 years' service with the company, have been presented with war savings certificates, a diamond centred gold medallion, and a framed illuminated address.

At the ceremony, over which Mr. J. T. Gray, managing director, presided, he referred to the recent amalgamation between the two long associated companies of J. F. Stewart & Company, Limited, and J. Gray & Sons, Limited, and recalled that the former concern was started in a very small way 22 years ago. Thus to have retained five members of the small staff for 21 years indicated the excellent team spirit which had continuously prevailed. The presentation was made by Mr. W. Thomason, the chairman, who gave a short history of the development of the company.

DESIGN AS RELATED TO CASTING PROBLEMS*

A call to the foundry industry to tackle the problems of casting design themselves

The cost of a casting is directly proportional to the complexity of design of that casting and to the problems pertaining to the production of that casting. A grey-iron jobbing foundry must be prepared to furnish good castings, varying in size and intricacy of design, regardless of the weight, which may vary from a few ounces to several tons per casting. The success or failure of a foundry enterprise depends upon the ability of its organisation to sell these castings at a competitive price and at a profit.

Castings design is as much of a selling problem as it is a production problem. The castings buyer furnishes working drawings, patterns or samples of castings needed and expects the foundryman to guarantee a price, weight and delivery to meet the buyer's requirements, when, as a matter of fact, it is the buyer himself who specifies the price, weight and speed of production because of his own casting design. Many a buyer, however, promptly proceeds to forget the price dictated by the design of his castings and expects to acquire a certain tonnage of cast iron at a price that will be attractive to himself.

This price will probably be less than the foundryman needs to produce the castings. This condition is particularly noticeable to foundries furnishing castings on a contract basis for a customer's entire needs, and it also exists where there is competitive bidding for job lots.

Foundries' Own Problem

The purpose of this Paper, therefore, is to point out why casting problems exist because of design, and to point out the fact that the solution of the problems must come from within the foundry industry. Foundrymen must sow the seeds harvested from their own experience, where the returns will be the greatest—among their own customers.

The castings business in a jobbing foundry is drawn from various industries manufacturing a multitude of products, and only in rare instances will a customer operate any type of foundry or have an adequate knowledge of the operation of a foundry. Who, then, are the ones responsible for the design of the castings made? They are engineers who are absorbed in perfecting a process of manufacture peculiar to their own industry.

Where Trouble Begins

These engineers are intelligent men or women, who have qualified for their position because of education or experience in their chosen line, which very likely has no connection with the foundry industry. Unless the designer has received his basic training in a technical school operated in conjunction with commercial shops, this school being either an educational institution or the training course of a comprehensive industry, it is very unlikely that the designer will have found time to have worked in the various basic types of shops to gain the necessary experience to appreciate the difficulties of shop practice.

A designer is a student, and as such will attempt to keep abreast of the times by studying new machinery applicable to his own process of manufacture. Also, he will study machine design, kinematics, and other basic subjects. He will have enough problems to solve in his own field and will not study publications intended for the foundry industry. With a problem at hand, he will arrive at a design by assembling standard machine parts and then the whole assembly will be tied together by the best-known medium—a casting.

From his text-books and advertising matter the designer will decide on the material from which the casting will be made, but the design or shape of the casting will be a product of his own inventive genius . . . unless someone can change his mind before it is too late. As far as foundrymen are concerned, it is "too late" after they have agreed to furnish poorly designed castings at a price and find themselves in trouble and faced with a loss because of the design of the casting.

Volumes have been written on casting and pattern design for the consumption of foundrymen and patternmakers and few experienced foundrymen cannot detect a poorly designed casting from one that is well designed. A competent patternmaker undoubtedly will design a casting and a pattern better suited to foundry practice than many engineers . . if the customer will pay for a pattern that is properly made.

Concise Data Needed

It is the author's contention, therefore, that, in spite of all of the fine publications on casting design, this information has not been utilised to best advantage. It would be far better for foundrymen if there was available a concise pamphlet edited, say, by the American Foundrymen's Association and obtainable at no greater cost than a good cigar for distribution among their customers, than to have their own libraries bulging with handbooks that tell them what they already know.

The latest treatises on machine design go into some detail as to how and why the physical properties of cast iron and other cast metals have been improved, and they also tell of the improved qualities to be derived from additions of certain alloys. Yet at no place do these publications point out that all of these improved qualities can be nullified by poor design.

* Presented before a meeting of the St. Louis District Chapter of A.F.A. The author is on the staff of the American Car & Foundry Co.

Design as Related to Casting Problems

What has the industry gained if it pours an expensive, high-tensile iron into a casting that will be full of stresses, cracks, draws or other defects? The whole purpose in improving castings is defeated unless proper design is coupled with quality metal. Where did customers get the idea that an ironfoundry should honestly produce cheap castings, or where did they get the hope that it could produce some of the designs submitted at all?

Design Instructions Quoted

It seems desirable to give by four quotations the sum and substance of instructions on casting design appearing in the latest American publications on machine design, edited by outstanding educators in the engineering profession . . . Masters of Science, if you please . . . works that are in general use in engineering colleges as well as in the field to-day.

(1) "Cast iron is the cheapest of metals and it is easy to manufacture articles of it."

(2) "Cast iron is more commonly used than any other material in making machine parts. This is because it can be given easily any desired form."

(3) "The principal advantage of cast-iron dies is the economy and speed with which they can be made. In some cases where a high degree of accuracy is not required, the die need not be machined. For such a die the pattern may be sent to the foundry one morning and the die made ready for service the next."

(4) "On account of cheapness, strength, ease with which it may be melted and cast into more or less intricate shapes, ease with which its hardness may be varied, cast iron is the most used of the cast metals used in engineering construction."

These remarks would seem to indicate that the wrong men are operating foundries, for if castings can be produced so easily and cheaply, why are to-day's successful bidders faced with a loss to-morrow? If castings are so easy to mould into any desired shape, why is the industry faced with casting problems because of design?

Reason for Casting Problems

Foundrymen are faced with casting problems due to improper design because the elements of casting design are not brought to the attention of designers. Inasmuch as authorities on machine design do not respect the problems of moulding and casting technique, it naturally falls to the lot of the foundrymen in general to educate their customers by exercising everlasting vigilance to eliminate poorly designed castings.

By these remarks it is not intended to infer that the engineering profession is lacking in ability, competence, or initiative. Quite the contrary. The salvation of the grey-iron foundry industry lies in the ability of the foundrymen to create the respect of the designers for foundry products and for the ability of foundrymen themselves.

When a poor design is submitted for a casting, take the time to go to the customer and explain exactly what he should do for his own best interests to get the casting that he needs, and such action will develop a mutual understanding and regard for each other's problems. The foundry will receive the respect that it deserves and it will be given every opportunity to put its products into use in his plant. However, if a foundry accepts orders for poorly designed castings, its costs will rise, deliveries will be late and its product inferior. Ultimately it will have lost a customer and, worse than that, the business may leave the industry because the intelligent designer will be quick to discover a substitute.

In recent years a new source of competition has made serious inroads into the foundry industry. For instance, in the "Engineering Science Series," published in 1934, the following observation is made under the heading of "Cast Iron":—"Welded steel construction as a substitute for castings has grown rapidly; it gives lighter weight for strength and stiffness and often costs less than castings."

Strive for Better Design

Therefore, it follows that the foundryman is not fostering an abstract ideal when he strives for better casting design. He is, in fact, fighting to preserve the industry which provides his bread and butter.

It would be impossible to tell foundrymen how to rig their patterns or how they should proceed to mould castings. There is probably as much ingenuity applied to moulding processes as in any other shop practice. A group of experienced foundrymen would probably offer several methods of moulding the same casting and all methods would produce good castings and would be efficient in accordance with their shop practice. There are, however, a few elementary facts which should be borne in mind at all times to effect a better casting design.

Foundry Should be Consulted

Impress the customer with the importance of consulting the foundry at all times on casting design and pattern construction. Do not accept a pattern or drawing as of final design until the weaknesses of the casting or suggestions for simplified moulding are pointed out to the customer. If it is impossible to talk with the casting designer and a request is made to quote on castings, mark suggested changes on the drawing in a contrasting colour and explain the reason for the change. Show any price differential that would result from the change. Give a reliable estimate of weights and do not assume that the weight shown on a drawing is correct. In this way the buyer will be able to judge how the suggestion will affect his price on each unit regardless of the pound price.

If asked to quote on a pattern, explain exactly how the pattern should be made to maintain the casting price. If this is not done, the foundry probably will receive a cheaply constructed pattern unsuited to current methods and estimates. Indicate the desired shrinkage allowance. In certain instances the foundryman will encounter customers who are niggardly about pattern expense. Explain that patternmaking is a skilled craft and that to employ carpenters, mainten-

ance men, or Jacks-of-all-trades to make patterns will lead to trouble, namely, inferior castings and high casting prices. Use and encourage the use of standard patterns colours.

Example of Cheap Pattern

Fig. 1 shows an example of cheap pattern construction which defeated the entire purpose intended. Patterns were received for cast-iron dies which were to

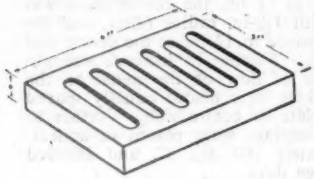
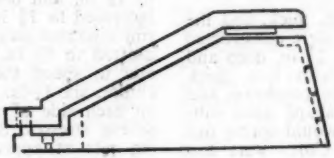


FIG. 1.



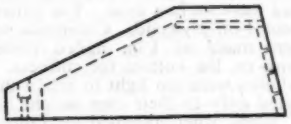


FIG. 2.

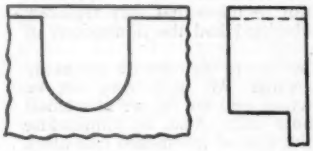


FIG. 3.

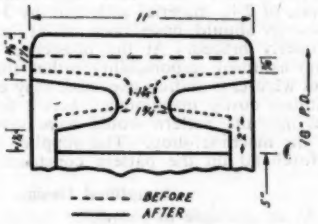


FIG. 4.

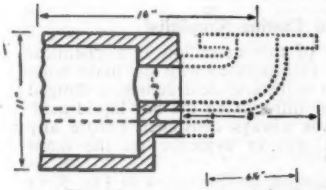


FIG. 5.

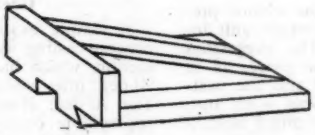


FIG. 6.

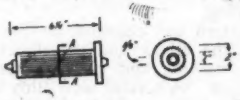


FIG. 7.

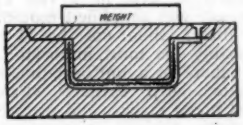


FIG. 8.

FIG. 1.—Example of cheap pattern construction that defeated its own purpose. Patterns were for cast-iron dies, to have smooth faces to be used "as cast" without further machining, and were made of ¾ in. plywood. Coreboxes were 2½ in. deep, made of 1 in. nailed lumber. At insistence of customer, patterns were used, but the dies cast required further costly machining. Patterns should have been of at least 1 in. material properly braced, coreboxes (as illustrated) approximately 6 in. deep of 2 in. material with 2 x 3 in. battens.

FIG. 2.—As a result of simplified design two castings (left) were designed to be cast as one piece (right), thus eliminating breakage, increasing the serviceability of the part, and lowering direct labour cost by 53 per cent.

FIG. 3.—Designing to eliminate shrinkage Original design (left) of a cast-iron kettle developed shrinkage in the top flange alongside a large side boss. As redesigned (right), the centre hole was cored and the outside of the boss cut similar to a flanged pipe, thus equalising the metal and overcoming the trouble.

Fig. 4.—How 18 in. heavy-duty chilled sprockets were redesigned to give superior products. To equalise the metal, hub thickness was reduced, centre plate increased, and rim thickness increased. To further increase strength, brackets were spaced equally on each side of plate or centre web, and stresses relieved by annealing and slow cooling.

FIG. 5.—Example of designing to eliminate a troublesome part, in this case a 90 deg. inlet elbow in a chemical process casting. Formerly, the elbow always failed before the main body casting. Its elimination reduced direct labour in moulding, coremaking and cleaning, and tripled service life of the part.

FIG. 6.—Pattern for a machine part, designed with loose wedge guide strips for casting in the cope, was returned and the strips fastened to the pattern, loose draws in pieces being made for the wedge as shown. Top brackets were made loose and cast in the cope. Foresight would have eliminated the extra pattern expense the design change necessitated.

FIG. 7.—A piece of machinery originally made of hardened tool steel and bronze bushed with oil grooves, was redesigned for production as a chilled iron casting, with a grey iron bushing replacing the tool steel part with the bronze bushing. Thus a new use for cast iron was developed.

FIG. 8.—Expensive cope and drag patterns furnished by a customer required machines a jobbing shop did not have, hence had to purchase the castings outside. To utilise its own equipment fully, the jobbing shop redesigned the casting to eliminate the cope, returned the work to its own shop, and produced uniform castings at a cost below the price paid for the castings outside.

Design as Related to Casting Problems

have had smooth cast faces, male and female, and the faces were to be used as cast without further machining.

The dies were 5 ft. by 6 ft. by 8 in. thick, and the face was cast in a core. The patterns were constructed from ¼-in. plywood. Coreboxes were 2½ in. deep and were made of 1-in. nailed timber with 1-in. thick strips on the bottom for stiffness. The coreboxes and patterns were too light to retain their shape when subjected only to their own weight and would spring out of shape when rammed or rapped. Cores were too thin to withstand handling.

The author explained to the customer that the coreboxes should have been approximately 6 in. deep, made of 2-in. material with 2-in. by 3-in. battens. The patterns should have been of at least 1-in. material properly braced. At the insistence of the customer, who assumed responsibility rather than lose time, the dies were cast and, as expected, they could not be used without costly machining. Just a few more shillings put into the pattern would have saved many pounds in the machine shop. The supplier is now consulted beforehand on the pattern construction.

Simplified Design

As an example of simplified design, the author previously made two castings to effect a certain unit installation, as shown in Fig. 2, left. The suggestion was made that the unit be cast in one piece, as in Fig. 2, right. Breakage was eliminated and the casting could be kept in service until it was worn out. The result was simplified moulding, a stronger unit, a lower direct labour cost by 53 per cent.

Probably the most important rule in casting design is to adhere to a uniform thickness of section and to eliminate sharp corners wherever possible. Sharp corners breed cracks, and proper fillets should be used at all times, taking care not to use fillets large enough materially to increase the metal thickness and cause shrinkage because of the fillet. Uniform thickness will reduce the induction of internal stresses because of uneven cooling and will minimise shrinks and draws.

Design Eliminates Shrinkage

A cast-iron kettle was being produced from a special acid-resisting alloy metal, designed as in Fig. 3, left. There was a shrinkage occurring in the top flange where a large side boss was cast adjacent to the flange. Proper risers would reduce the trouble, but would not eliminate it. This boss was for a flange connection. The centre hole was cored, thus eliminating drilling, and the outside of the boss was cut similar to a flanged pipe, as shown by Fig. 3, right. The metal was equalised in this manner and the trouble was overcome.

Sprocket Design Changed

An inquiry was received for 18-in. P.D. heavy-duty chilled sprockets with an 11-in. face. The drawing called for a 2-in. thick hub, 1 1/16-in. centre web, and ½-in. thick metal under the rim. In pouring these castings it is essential that the hot iron comes to rest against the chiller as soon as possible to avoid flaws in the chilled surface.

To equalise the metal the hub thickness was reduced to 1¾ in. and drafted to 1½ in., the centre plate was increased to 1¾ in. with 1 1/16-in. radius fillets, and the rim thickness was increased to 1⅛ in. at the centre and drafted to 1¼ in. thick. Further to increase strength and to speed the rate of flow of the metal to the chiller, six 1¼-in. brackets were placed equally spaced on each side of the plate or centre web. Further to relieve stresses, these castings were placed in annealing pits at approximately 760 deg. C. and allowed to cool slowly for three days.

The above change in design, shown in Fig. 4, was readily approved by the customer and the sprockets proved to be far superior to those that they replaced. The drawing as first submitted had the dimensions of the original sprockets.

Beware of castings that try to incorporate too many features in the one casting. All parts may not be subjected to the same action, and the failure of a small part may scrap the whole unit. Also, by eliminating the troublesome part, the size of the mould can often be reduced and hence the cost will be reduced on a casting that will give better service.

Chemical Casting Simplified

A simple example of this condition is a chemical process casting which incorporated with the main body section, which had to withstand acid fumes, a flanged 90-deg. inlet elbow for introducing the hot liquid acid. The 90-deg. elbow was always consumed before any appreciable corrosion was in evidence on the main body casting.

The pattern was changed, as illustrated in Fig. 5, to eliminate the elbow and the direct labour in moulding, core making and cleaning was reduced on the body casting. A special high alloy acid-resisting elbow was used which could resist the hydraulic cutting action of the acid. In this way an installation was achieved that, in the long run, cost less than the original casting, and the apparatus was kept in operation approximately three times longer between replacements. The customer was pleased and consulted the author further on apparatus that his foundry had not previously furnished.

Patterns should be so designed that machined surfaces can be cast in the drag, if possible. Sufficient machining metal should be allowed to enable a cut to be taken below the skin or scale. Where sections are of unequal thickness, it has been found that the skin of the metal carries a large proportion of the stress set up in the casting. Hence, if highly accurate machining is to be done, these castings should be annealed and allowed to season after the roughing cut is taken.

Cutting Extra Pattern Expense

The pattern for a machine part was delivered to the foundry with loose wedge guide strips for casting in the cope. This pattern was returned and the strips

were fastened to the pattern and loose draws in pieces were made for the wedge, as shown in Fig. 6. The top brackets were made loose and were cast in the cope.

A little foresight would have eliminated this extra pattern expense. However, if the foundry had proceeded to furnish the castings with the pattern as offered, it probably would have received a complaint that the machined surface would not clean up. In this instance the draw in pieces can only be eliminated by a core, but in all instances draw in pieces should be eliminated wherever possible, because draws in pieces are often hard to handle and a broken mould is hard to patch.

Developing New Uses

New and novel applications for castings can be discovered when the designers' problems are appreciated by the foundryman. Be sure that the customers' engineers, as well as purchasing agents, know the various types of metal that the firm produces, so that the proper casting can be made for its particular use.

One indispensable piece of machinery was made of hardened tool steel and bronze bushed with oil grooves. However, so many of these articles were being used that replacements were developing into a sizeable item of operating expense. The procedure to make the article consisted of turning a steel blank, boring and milling the blank to have longitudinal teeth. This part was hardened and the bronze bushing installed. Flanges were then shrunk on the ends.

The author offered to produce a chilled iron casting to replace this part, designed as illustrated in Fig. 7. It was necessary that the teeth be uniform and the body had to be round to replace the machined article. A machined steel stripping plate corebox was made to form the teeth and a loose piece made the flange. A block with core prints was rammed up in the sand. The core was installed to form the outside of the casting and a centre core of grey cast iron was placed in the centre prints. The mould was poured with iron that would chill readily.

The customer had only to cut off the cast-iron core prints, bore the centre hole and cut the oil grooves, and he had a chilled casting with a grey iron bushing to replace the tool steel part with the bronze bushing. Thus a new use for cast iron was developed and these castings are being used to-day in quantities.

In the operation of a strictly jobbing foundry, as against a production shop, the author has been reluctant to instal costly production machinery with its attendant pattern and flask equipment to carry a few quantity jobs. Idle machinery is a greater problem than no machinery at all.

A Jobbing Shop Problem

In one instance a customer furnished expensive cope and drag plate patterns to cast one casting per mould, and the foundry did not operate the proper type of machine to make use of the patterns. These castings were purchased by the author from a production shop rather than to have installed the moulding machine and to have been faced with stepping out of the field to sell enough production work to keep the machine busy. This arrangement was profitable, but the foundry was not pleased to lose the tonnage from its own heats.

In redesigning the job (Fig. 8), the hand moulding patterns were equipped with core prints and fastened to a board. A corebox was made to include the lift formerly in the cope and included a cover core vented and complete with a gate and pouring basin. In this way the cope was eliminated and the core was a convenient size to handle. The work was returned to the jobbing shop and it then produced uniform castings by hand at a cost that was materially below the price it had been paying the production shop for the castings.

Where Foundry Troubles Begin

There probably are more pertinent examples than these to illustrate the problems caused by casting design, because every casting is a separate problem. If foundrymen find themselves in trouble trying to make poorly designed castings, they have no one to blame but themselves because they accepted the business without question. Foundrymen themselves will have to exert the pressure to eliminate faulty casting design and in this way reduce their losses and improve their products.

Most of a foundry's troubles begin with inquiries and patterns, and there is the place to eliminate trouble before it gets on the moulding floor. In this way casting problems caused by design can be greatly reduced.

BOOK RECEIVED

British Railways in Peace and War. Issued by the British Railways Press Office, Waterloo Station, London, S.W.1. (Price 1s. net.)

The new booklet does not appeal to the reviewer quite as much as earlier publications, because of the lack of collected statistics. One felt rather superior when one could cite the number of stations, the longest tunnel, etc., to one's pet nephew. However, that is merely a very personal point of view and, to do justice to the publishers, it should be pointed out that this issue, which gives more details about London Transport, is, if anything, better illustrated—there are 66 pictures in its 72 pages—than earlier publications. Moreover, the letterpress is enlightening and well written. It is an ideal booklet for train reading and passing along to either old or young railway "fans."

Foundry Queries

Rust Prevention.—A further offer of help in connection with the prevention of the rust of castings between sand blasting and later processing has been received from Wm. Cumming & Company, Limited, Kelvinvale Mills, Maryhill, Glasgow, N.W.

"The Missing Technologist."—We regret that we printed the name of the author of this book as Mr. John Goag instead of Mr. John Gloag.

QUALITY CONTROL IN HIGH DUTY IRON PRODUCTION*

By E. W. HARDING
(The International Meehanite Metal Company, Limited)

Enthusiastic discussion centres around definition of "quality control"

DISCUSSION

MR. J. F. KAYSER (Branch Vice-President), commenting on some curves showing the frequency distribution of results, said that he had something like 2,000 frequency distribution curves, but none of them was normal. He asked if Mr. Harding could explain that fact.

MR. HARDING replied that his interpretation of the term "normal distribution" as applied to a curve was that it was derived from an infinity of results.

MR. KAYSER said that his curves were produced by 700, and sometimes 1,000, results.

MR. HARDING explained that when dealing with a chart based on the frequency distribution curve he was dealing with averages, and the curve for averages would always tend to be more normal than the curve for individual results. He also pointed out that for control work one did not need or expect an absolutely theoretical curve. Indeed, one obtained a curve which was based, not on the actual results obtained, but on the results required. In other words, limits were based, not on the results obtained, but on the results which it was contended should be obtained. In reply to Mr. Kayser's suggestion that one did not want a normal curve, but a curve more to the right on the graph, Mr. Harding said he could not agree. He was interested at the moment in establishing standards and basing the limit line on those standards.

The Test-bar Graph

MR. C. CLEAVER, discussing a graph which showed average tensile results and also the range of tensile results, *i.e.*, the difference between the highest and the lowest results, asked why the test-bars used in one foundry were of the dimension 0.505 in. (after machining).

MR. HARDING replied that that was a special case. The 0.505 in. was not a standard test-bar dimension; but the size had no significance. The tests were carried out in the various foundries, using the particular practice and the particular test-bar dimensions adopted in each foundry. It was not the purpose to determine the relation between the foundries; he wanted to know the variation in each foundry, under the particular conditions operating there. There was no particular relation between the test-bar dimensions and the range of results. But one of the greatest causes of variation of test results was the machining or finish of the bar; badly machined bars invariably showed a high range, irrespective of the dimensions of the bar.

MR. KAYSER pointed out that in one case the range of tensile results was 1½ tons per sq. in., whereas in another the range was as much as 4 tons per sq. in. He asked if there were any material difference between the two.

MR. HARDING said that in the case of the foundry showing the range of 4 tons per sq. in., using six test-bars made from the same ladle of metal, the results indicated, in his view, a most serious condition.

MR. KAYSER said it was possible to show that the test was not a statistical test.

MR. HARDING agreed that it was not. The purpose of the test was to find out what proportion of the total variation could be attributed to testing, as distinct from melting practice. The test bore no relation to the practice of the particular foundry; he did not suggest that all the ladles in that foundry would yield such results.

MR. KAYSER said the possibilities were that, if another sample were taken, using 12 bars instead of six, the results as between Foundry No. 1 and Foundry No. 4, as shown on the graph, might have been reversed.

MR. HARDING agreed, but he emphasised that that was not the point. However, there was in fact a tensile range of more than 4 tons per sq. in.

Dealing with a remark by Mr. Kayser that it did not mean anything, MR. HARDING said it meant that it was possible to produce such a range of results without metal variation; it indicated that the testing needed investigation. and that one must not assume that the wide range of the results was due wholly to the melting practice in that foundry. The only point he was trying to drive home, with the aid of the graph, was that variations due to testing did occur. He agreed that a foundry showing a variation of 0.54 ton per sq. in. might on the following day produce a variation of 6 tons per sq. in.

A SPEAKER said he gathered the assumption was that, by using six test-bars which were cast almost together, possible causes of variation in the metal itself were eliminated. Mr. Harding was focussing attention on the possibility of variation due to measurement; where there was so big a variation, he would claim that it was due to variation in the testing, and could not be due to variation in the metal.

MR. HARDING agreed, and said he was dealing with errors of measurement.

Temperature Control

A SPEAKER asked if it were assumed that all the six test-bars were poured at the one identical temperature.

MR. HARDING said that the ladles used contained

* See our issues of March 16, 23 and 30, 1944.

quantities of from 10 to 15 cwts. of hot metal. Six test-bars were poured from one test ladle, and the time which elapsed between the pouring of the first and the last test-bar would not be more than about 1 min. The temperature decrease during that time was very small. Moreover, the variation of results obtained with the test-bars did not occur in the order of pouring. The variation between the middle test-bars might be greater than the variation between the first and the last. He agreed that the pouring temperature was quite an important matter, but the temperature variation could not be more than 5 or 10 deg. C. The greatest cause of variation in the results was the machined surface of the test-bars.

A SPEAKER, discussing a control chart showing a high tensile on Meehanite "G.C.," asked if it would be true to say that the chart indicated that too good a product was being made.

MR. HARDING replied that it did not. He was not concerned as to whether the product was good or bad in the sense that the tensile strength was high or low. If a foundry were aiming at a tensile strength of 19 tons per sq. in. for a type "G.C." Meehanite, and produced an iron of 25 tons per sq. in. tensile, it would be a very bad result. He was concerned to set a standard and to produce uniformly to that standard.

Excessive Complication?

MR. KAYSER, in a general criticism, said that any system of quality control was better than none at all; but why one should go to so complicated a method of control as that described in the Paper was really beyond understanding. It seemed to him that the country had gone mad on statistical methods; he could only think it was because the insurance companies had had to dispense with actuaries, and that the latter had gone into the factories! One might read in a technical journal that in a certain foundry or factory, prior to the introduction of quality control, the percentage of scrap was 25, but after the introduction of quality control it was 0.03. Had he been the manager of that factory he would immediately have introduced "Music While You Work"; the percentage of scrap would then have fallen immediately to a very small figure, not because of "Music While You Work," but in spite of it!

Continuing his criticism of statistical methods of control, Mr. Kayser recalled having attended a meeting some time ago which was addressed by Dr. B. P. Dudding, and at the end of his lecture he (Mr. Kayser) had asked whether or not the audience had understood it. Of the 46 people present, only three had stood up, and they indicated that they had only an idea of it. Unfortunately, that had been the experience of all his colleagues who had attended lectures on the subject, said Mr. Kayser. Frankly, but for the fact that he had devoted a great deal of time to the study of control for many years, he would not have had the remotest idea of what Mr. Harding's Paper was about.

The use of "standard deviation" worried him. Why not use "mean deviation," for it meant one more operation to calculate "standard" than "mean" deviation? As to Mr. Harding's assumption concerning the normal distribution curve, he said he had seen vast numbers of distribution curves, for the reason that for more than ten years he had had to produce an article at the rate of from one to three millions per day; the number of tests had never been less than a thousand per day, and sometimes it was more. From those tests one could obtain much data and all sorts of curves. There were certain properties that might give a curve with two definite modes; he and his colleagues had found out the reason, and they had come to recognise it, and all was well.

In his view one should adopt the practice of plotting the results as they came along, and then one could see how they varied. One wanted to see the maximum and the minimum. He fully appreciated the meaning of "standard deviation" and "mean deviation"; but he urged that they were different conceptions, and he did not think one needed them. It seemed to him that it would not be economical to use them. One might apply the method of inspection described by Mr. Harding to a foundry which was in a bad way and, by an expenditure of, say, 1,000 working hours per year, one would achieve a certain result. Mr. Kayser urged, however, that by a more simplified method of quality control one could achieve the same result by an expenditure of only 500 working hours per year.

As showing that he was not alone in his criticism of statistical methods of quality control, he said he was associated with an engineering concern having batteries of machines producing parts at a very high rate; the view there was that statistical methods were not on the way in, but on the way out.

Nevertheless, he was of the opinion that in all firms there should be a technician with a knowledge of statistics. To illustrate his point, he recalled a graph shown by Mr. Harding indicating the tensile test results obtained in various foundries. Foundry No. 1 showed an average of about 17 tons per sq. in., with a range of about 1.5 tons per sq. in., whereas Foundry No. 4 showed an average of 17 tons per sq. in., but one result was as high as 20 tons per sq. in. Assuming that the graph was representative of the true tensile properties of the castings rather than of tensile test results, he said that the first reaction of a buyer who had just a commercial instinct would be to buy from Foundry No. 4, because the results seemed to be a little better than those of No. 1 Foundry. It would appeal to such a buyer that one casting in each six bought from Foundry No. 4 would give an extra 3 or 4 tons per sq. in. But it did not follow that it would be advantageous to buy from Foundry No. 4, and anyone with an eye to statistics would appreciate that.

Pleading again that one should not use the term "statistical control" when considering an engineering product, and that there was no need to introduce the terms "mean deviation" or "standard deviation," he said that if one plotted the maximum and minimum results and watched the range carefully, it would be

Quality Control

understood by far more people than could understand "standard deviation" and similar functions.

Aim of the Statistical Method

MR. HARDING commented that Mr. Kayser had evidently a strong objection to "standard deviation," but apparently he had not appreciated the aim of the statistical method described in the Paper. The standard deviation was not actually used; but even if it were, it would still be true that the aim was to find out whether or not the foundries concerned were producing to standard for Meehanite metal in regard to the magnitude of the value and in regard to the consistency. Whether or not one used statistical methods did not matter; any method that would give that information would do. Formerly, in common with all other foundries, individual results were plotted in order to find out whether or not one was working within standard. But by plotting individual results one obtained a most confusing picture, and one might easily miss a trend which could not be missed if the results were grouped.

Although Mr. Kayser was comparing control of the machine shop and the foundry in respect of statistical methods, there was in fact no comparison between the two; the conditions were entirely different. Evidently some snags had arisen when applying such methods in the machine shop; there the difficulty was that there were so many machines and so many products.

MR. KAYSER disagreed and pointed out that he was discussing the production of one article at the rate of from one to three millions per day.

MR. HARDING said he gathered that Mr. Kayser was talking about the control of each different machine.

MR. KAYSER asked if Mr. Harding would deal with the control of just one machine, having a minimum output of one million per day.

MR. HARDING agreed that as between one melting plant and one machine a true comparison could be made; but as between one melting plant and a hundred machines one could not make a true comparison. He was discussing the control of the product from one melting plant; and the statistical method which he had discussed did not involve anything like an expenditure of 1,000, or even 500, working hours per year.

MR. KAYSER said that, for purposes of discussion, one could assume 1,000 minutes or any other units of time.

MR. HARDING emphasised that his method of control was by no means involved; it was the simplest of processes. There was perhaps a type "G.C." Meehanite coming through every day, and one test was taken, so that after six days one had a sample. The calculation of the average and the range on that sample of six occupied only about 2 min.; one had simply to calculate the average of six and subtract the minimum from the maximum of those six. Thus, there was not much clerical work involved. If the metallurgist could not afford two or three minutes per week to make that calculation, there was something wrong.

With regard to testing technique, he suggested that Mr. Kayser had misunderstood the graph. It had nothing to do with the product properties of the foundry. All that the graph on testing technique aimed to show was that other factors than melting might be responsible for test result variation. That point was proved.

MR. KAYSER suggested going a little further and assuming that the variation was due to difference in methods, and not to testing.

Variation Not Due to Metal Properties

MR. HARDING said he did not want to assume that, because it was not the lesson he wished to teach. Two foundries might, and would, differ in respect of metal properties; that was another matter. His point was to show that the variation was not due to metal properties.

Coming back to the original question as to why statistical control should be used at all, he said the alternative was the method which had been used for years, *i.e.*, to take tests every day, to look at them and to say they were not bad, and to let them go. That did not indicate a great deal. One might obtain metal from the cupola which showed a silicon content of 1.6 per cent., whereas one wanted a silicon content of 1.8 per cent. One might look at it and comment that the silicon content was a bit low, but that it was all right. Next day the silicon content might be 1.55 or 1.58 per cent.; and again one might let it go.

MR. HARDING, continuing, said he did not mind whether one used standard deviation or range; but his objection to standard deviation was the difficulty of calculation. On theoretical principles it was distinctly the more accurate estimate of variation, but he did not use it because it was a little difficult to calculate, and the calculation involved time. There was no inherent disadvantage in its use as compared with range; indeed, range was less accurate, but it was used because it was easier to calculate.

The objection to statistical control on the ground of complexity, as put forward by Mr. Kayser, might be based on the multiplicity of charts in a machine shop, but this compared with the simplicity of the system as applied to one melting plant in a foundry.

MR. E. M. CURRIE said he would not enter the lists against Mr. Kayser; but one must aim at consistency. He would say to any buyer that surely it was desirable to be able to buy castings from a foundry in January and in the following December and to know that all those castings possessed the same physical properties. How could one machine them in the same way, at the same speed, and so on, unless there were consistency in respect of properties?

The suggestion that the system described in the Paper was so difficult that the meeting had not understood it seemed rather to be an insult to the members' intelligence. One had not to be a lover of higher mathematics in order to understand the application of such a system. He did not worry about the way in

which the system was built up; he wanted the information which the charts contained. When confronted with a mass of 300 or more figures, representing perhaps six months' working, he could not see the wood for the trees; but a small chart which represented six results and showed the average between them was very easy to understand. He assured Mr. Kayser that that system was being used nowadays by average metallurgists in several foundries, and they had found that their work was lessened and not increased by taking the results at the end of each week and putting one spot on a chart.

One of the best explanations he had ever heard of a metallurgist's work was one in which it was compared with that of a map maker, whose maps were marked with dots for cities, with lines for rivers and roads, and so on. Those lines and dots indicated to the traveller the direct route to his objective, just as the chart indicated to the metallurgist that he was achieving consistency, or how far he was deviating from it. Experience had shown definitely that quality control in the foundry was a really valuable tool. Was not the foundryman striving for consistency from start to finish?

Test Procedure

MR. MCRAE SMITH said he could not understand why, in regard to testing the differences in values from mechanical tests, the test-bars were not all cast in a common mould or common core, *i.e.*, all six test-bars off the same runner, in order to eliminate variations in cooling conditions, and so forth. It seemed to him that method would give a truer criterion of the difference in tensile and other properties. He also asked whether the bars were screwed and whether they were in self-aligning machines.

Referring to the charts showing silicon and carbon variations, he asked what experimental error was allowed in respect of carbon determinations, for he had found, particularly in the so-called consulting laboratories, and so forth, that there were sometimes very wide experimental errors in the determination of carbon content?

MR. HARDING replied that the carbon variation shown on the charts was the total variation, which included testing errors.

MR. MCRAE SMITH commented that the limits seemed to be very close; it was a question of only ± 0.1 per cent.

MR. HARDING emphasised that the ± 0.1 per cent. was for the averages, and not for the individual values; that made a great difference. The difference in the individual results corresponding to the average difference of ± 0.1 per cent. would be ± 0.25 per cent., and that was a big variation. Tests had been made for variations in carbon and silicon contents just as they were made for tensile differences, and there was a difference in all cases of about 0.05 per cent. It was true that an allowance of ±0.1 per cent. on the averages appeared at first glance to be very small, but actually it was a very wide limit, and it was the aim to reduce that limit.

As to the suggestion that all the test-bars should be cast in a common mould or common core, he agreed that that would be desirable if one were concerned purely with testing tensile consistency; but he was concerned with both the tensile consistency and the sampling practice. The various foundries all used different practices with regard to grips and conditions generally, and he adopted the regular practice in each foundry.

MR. LESLIE V. WHEELER, C.A., speaking as a "practitioner in statistical theory," and commenting on Mr. Kayser's challenge, said he could not understand why it was always levelled at the head of the statistician as a fault if ever he should arrive at a conclusion which agreed with that of his consultant; that agreement occurred frequently, when two people were looking for the truth and both found it!

He was particularly pleased with the Paper, for in it Mr. Harding had demonstrated as well as one could demonstrate at a meeting the fact that that particular use of statistical methods provided a tool which could do very precisely things which could not be done in any other way. One could refrain from using it if one were so disposed; but it was there to be used, and he felt sure Mr. Kayser would agree that there were occasions when, by the use of that tool, one could answer questions which the technician alone had not been able to answer. The statistical method of quality control would very frequently enable one to put one's finger on the source of an assignable cause of error which otherwise could not be traced.

MR. HARDING, enlarging upon Mr. Wheeler's remarks, said that sometimes it had been found, on plotting results on a chart, that although the average value might be quite satisfactory, the range of values was wide. By sub-dividing the results according to various factors—*e.g.*, separating the results for different cupolas and plotting them on separate charts—one had been able to locate a cause of trouble which otherwise might not have been located for months. The statistical method had been of great value in that way alone. When foundries had been using the charts for some time they began to know where to look for their troubles. When he visited a foundry, he always asked first for the charts, and after examining them for a few minutes and studying the results for, say, two or three mixes, he knew where to look for trouble; he had not to walk around asking various people what was right and what was wrong. By his perusal of the charts he obtained a fairly good idea of what was wrong, before he went into the actual foundry; but he had never been able to do that before the chart system was adopted.

MR. KAYSER agreed that the charts were all-illuminating to anyone who had to go into a works to examine results and find out what was wrong. But that was not quality control. Quality control must be right on the spot. He did not like to hear people say what they did on a Saturday to average their results. What about the result obtained late on Tuesday night? One needed to check that there and then;

Quality Control

and that was where he did not think Mr. Harding's method did its job.

MR. HARDING was not sure what Mr. Kayser meant by "quality control" in that case.

MR. CURRIE said he presumed the point was that one must have the individual results before one could arrive at groups. Obviously, if on Tuesday night the results achieved were quite outside those for which one was aiming, one could do something about it immediately. At the same time, one wanted to know that consistency was being maintained over a long period.

MR. WHEELER added that, presumably, if there were a bad result on Tuesday night, one would have been warned of it on the previous Thursday if one had used the statistical method.

MR. KAYSER said it appeared that the difference between them was in the definition of "quality control."

Vote of Thanks

MR. G. C. PIERCE (Past-Branch-President) proposed a hearty vote of thanks to Mr. Harding for his Paper, which, he said, had been very enjoyable. Those who were fond of figures, he continued, had had a field day, but he was engaged in the manufacture of castings. While he appreciated that test-bars were necessary, it should be borne in mind that the foundryman was concerned with other things besides the production of test-bars. He, personally, could produce a very good test-bar and a bad casting sometimes; that was a problem which had still to be solved, and he would have liked to have heard more from Mr. Harding about the value of the test-bar results in relation to the castings.

DR. A. B. EVEREST (Past-Branch-President), seconding the vote of thanks, said that the Paper had been most entertaining, and the enthusiasm of the discussion was an indication of its value. The point was that a foundry must keep records, and Mr. Harding had shown a method of interpreting those records. There were other methods, of course. One might, for instance, just plot each record and obtain a curve, and by studying that curve one could obtain clues without going deeply into statistics. However, that was a personal opinion; he was very interested in the system described in Mr. Harding's Paper, and it was a pleasure to second the expression of thanks to Mr. Harding.

MR. HARDING, in the course of his response, commented jocularly on Mr. Pierce's remarks, which led him to recall a well-known comment to the effect that there were three kinds of lies—lies, damned lies and statistics. With regard to Mr. Pierce's question as to whether, from the test-bar results, we could get down to the castings, he said that we were on the way there. It was necessary to deal with one thing at a time. It was a matter of controlling operations, and the factor to start with was the metal. Later there would be similar control of the sand and other factors.

NEWS IN BRIEF

A DEPARTMENTAL COMMITTEE is to be set up to examine adult education and the whole question of the relationship of the universities and technical colleges, MR. R. A. BUTLER, President of the Board of Education, told the House of Commons during discussion in Committee of the Education Bill.

BAYLISS ROLLS, LIMITED, has been registered as a private company with a capital of £150,000 in 150,000 £1 shares. The objects are to acquire from Bayliss, Jones & Bayliss, Limited, and John Lysaght, Limited, those portions of the businesses relating to the manufacture of rolls, and to carry on the business of iron, steel and brass founders, metal workers, etc. The directors are: Messrs. O. F. Grazebrook, R. P. Perry, P. S. Bayliss, Wm. A. Nicol, H. E. Cookson and Wm. H. Lewis.

AN EXTRAORDINARY GENERAL MEETING of John Dale, Limited, manufacturers of metal containers, etc., is called for April 12, to consider a special resolution for increasing the share capital by the creation of 75,000 redeemable cumulative second preference shares of £1 each. The object of the proposed increase is to provide cash to enable the company to exercise its option to purchase the freehold of its factories at London Colney, Herts, together with land for further development; to repay money borrowed by the company; and to provide a fifth factory to enable the company to carry out certain specialised work.

AT THE ANNUAL MEETING of the Millom & Askam Hematite Iron Company, Limited, held at Carlisle on March 29, SIR ANDREW LEWIS (chairman) said that the blast furnaces maintained full production throughout the year. The ore sintering plant also maintained a satisfactory output, and was of material assistance in maintaining pig-iron production. The Florence iron ore mines maintained steady production throughout the year. A new shaft was now being sunk outside the ore deposit. The mines of the Alquife Mines & Railway Company, Limited, had met all demands for production and deliveries. At Ullcoats mines satisfactory production had been maintained throughout the year. The crushing and screening plant should be ready to go into operation within a few weeks.

John Baker & Bessemer—Report for 1943 states that the profit on many "costed" contracts is not settled, and that the tax calculations are based on the standard profit as agreed for the standard period. The directors are of opinion that any adjustments which have to be made will not have an adverse effect on the accounts as presented. After allowing £59,234 for income-tax and E.P.T. and providing for all other charges, including depreciation, the surplus for the year is £25,500; brought in, £23,413; written off war damage insurance, £1,814; preference dividend, £7,820; dividend of 10% (same) on the ordinary shares, £12,397; forward, £26,880.

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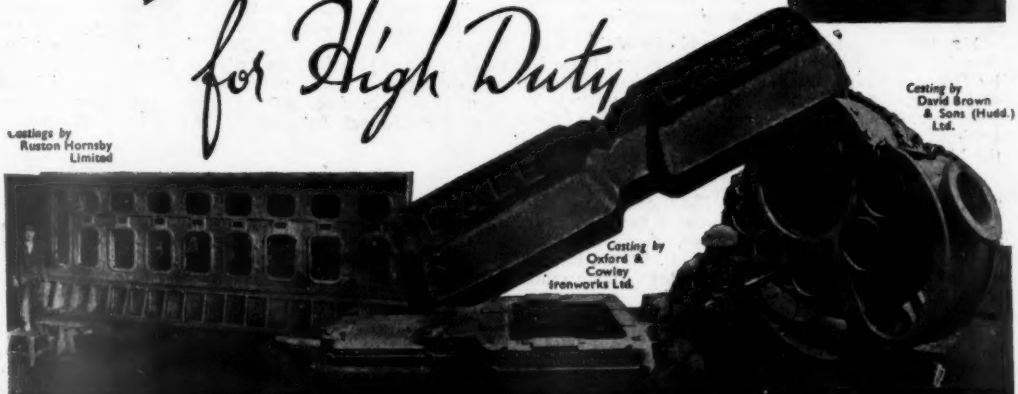

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PERSONAL

MR. T. W. JOB and MR. W. H. SPENDLOVE have been appointed to the board of the Halesowen Steel Company, Limited. MR. A. F. BEACH is appointed secretary.

MR. ARTHUR WHITELEY, formerly of Ley's Malleable Castings Company, Limited, has been appointed managing director of Glanmor Foundry Company, Limited, Llanelly.

MR. A. C. MACDIARMID, on his appointment as president of the British Iron and Steel Federation, has resigned his seat on the board of the Wellman Smith Owen Engineering Corporation, Limited.

MR. H. M. LONGRIDGE, who has retired from the position of general manager of the British Engine Boiler & Electrical Insurance Company, Limited, will be succeeded by Mr. R. R. Mason, at present submanager of the company.

MR. E. HUGH ARMITAGE has been appointed chairman of Brown Bayley's Steel Works, Limited, Sheffield. He is the son of Mr. Robert Armitage, who died in February. When his father retired in April, 1940, Mr. E. Hugh Armitage was appointed managing director.

MR. A. H. MIDDLETON, of the Consett Iron Company, Limited, is to receive the honorary degree of Doctor of Civil Law from Durham University. Mr. Middleton is a coke expert. He is a past president of the Coke Oven Managers' Association, and is at present chairman of the Northern Coke Research Committee, which office he has held since 1935.

MR. W. BARNES, of Nettleham, Lincoln, is retiring from the service of Ruston-Bucyrus, Limited, and commencing business on his own account as a consulting engineer for excavating machinery. Mr. Barnes has had 40 years' experience with Ruston & Hornsby, Limited, and Ruston-Bucyrus, Limited, in the design, sales and application of excavating machinery.

MR. J. H. WHITELEY, chief metallurgist of the Consett Iron Company, Limited, is to have conferred upon him by Durham University the honorary degree of Doctor of Science. Mr. Whiteley's researches are well known, and were recognised last year by the Iron and Steel Institute, when he received the Bessemer Gold Medal, the highest honour awarded by the Institute.

MR. R. H. HOWATT, formerly manager of the Birmingham office of the Brush Electrical Engineering Company, Limited, has been promoted to an executive appointment at the head office and works of the Brush organisation at Loughborough. MR. E. LESLIE BROOKS has been appointed manager of the Birmingham office. Mr. Brooks was chief technical sales engineer of Petters, Limited, a subsidiary of the company, in which capacity he was well known in the South and West of England.

Will

HILTON, SIR ROBERT S., of Shipston-on-Stour, deputy chairman and managing director of the United Steel Companies, Limited, and a director of other companies £24,250

COMPANY RESULTS

(Figures for previous year in brackets)

Halesowen Steel—Final dividend on the ordinary shares of 17½% (same), making 25% (same).

Blythe Colour Works—Profit, £25,761 (£33,506); tax and N.D.C., £14,250 (£17,000); dividend of 5% (same); to general reserve, £5,000 (£6,000).

Vulcan Foundry—Net profit for 1943, £24,280 (£24,968), after deducting taxation of £144,833 (£118,479); dividend of 5% (4%); forward, £44,526 (£43,873).

Newman Industries—Profit, after depreciation and obsolescence, £70,978 (£67,182); taxation, £41,000 (£33,000); dividend of 20% (same); forward, £18,014 (£16,606).

Parker Winder & Achurch—Trading profit for 1943, £43,439 (£58,878); net profit, £16,139 (£10,577); ordinary dividend of 10% and bonus of 5% (same); to war contingencies, £5,000 (nil); forward, £22,551 (£19,147).

General Refractories—Trading profit for 1943, £228,283 (£247,174); interest, £3,437 (£10,393); depreciation, £39,222 (£39,941); A.R.P., £2,916 (£5,208); taxation and E.P.T., £130,722 (£129,543); profits attributable to outside interests, £2,583 (£1,504); war damage insurance, £1,528 (£2,139); to general reserve, £25,000 (same); dividend of 7½% (same); forward, £54,033 (£55,665).

Gibbons (Dudley)—Net profit for 1943, after providing for taxation and depreciation, £33,806 (£33,002); 7% preference dividend, free of tax, £2,100; dividend of 10% on the ordinary shares, less tax, £6,687 (same); bonus of 5% (3½%) on the ordinary shares, £3,344; written off buildings and plant, £3,000; to reserve for deferred renewals and repairs, £10,000; to reserve fund, £5,000; forward, £22,254 (£19,478).

English Steel Corporation—Profit for 1943, after an allocation to reserve for deferred repairs and post-war and other contingencies, £726,190 (£708,958); fees and debenture service, £82,322 (£82,318); depreciation, £350,000 (£300,000); net balance, £293,868 (£326,636); dividend on the 7% preferred ordinary, and dividend of 17½%, tax free, on the deferred ordinary shares, £275,956 (same); forward, £175,647 (£157,736).

NEW COMPANIES

("Limited" is understood. Figures indicate capital. Names are of directors unless otherwise stated. Information compiled by Jordan & Sons, 116, Chancery Lane, London, W.C.2.)

H. Joynes & Company, 15, Daisy Street, Halifax—Brassfounders, etc. £3,000. H. Joynes.

Heppenstall & Sons, Wembley Street, Gainsborough, Lincs—Engineers. £20,000. W. and A. D. Heppenstall.

Arthur Abplanalp—Engineers, etc. £1,000. A. H. D. Fairbarns, 11, Sheffield Street, London, W.C.2, subscriber.

J. & Riley Carr—Steel manufacturers, tool makers, etc. £7,500. R. M. Carr, 7, Tapton House Road, Sheffield.

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Raw Material Markets

IRON AND STEEL

Widely varying conditions prevail in the foundry trades. Slackness in the light-castings trade persists, and at other establishments contracts for certain classes of castings have been cancelled. On the other hand, the general engineering and allied foundries have heavy programmes in hand, chiefly for tanks, aircraft and armaments. Unfortunately, difficulties are still experienced in regard to coke supplies. There is plenty of coke available, but transport facilities are still difficult, and most of the foundries are working on a hand-to-mouth basis. In regard to pig-iron, the position is more favourable. Most of the foundries have good stocks, and the blast furnaces also have substantial reserves in hand. Even low-phosphorus iron is now obtainable without much difficulty, and is extensively used as a substitute for hematite, the output of which is strictly reserved for special purposes. It is obvious, however, that a more stringent position is developing with regard to pig-iron. The exigencies of the present situation demand the freeing of the railways to the greatest possible extent in order that they may carry out the task that lies before. Foundrymen have been informed of the position, and realise that some curtailment of both production and consumption of pig-iron is entailed. Scrap is noticeably tighter, and it is not now possible to secure high-phosphorus iron to replace scrap supplies.

During the past two or three weeks deliveries of home produced steel semis have been on a less satisfactory scale, and as the requirements of the re-rolling industry are still at peak levels, users have had to encroach upon their reserve stocks. Liberal use is also being made of defective billets, slabs and blooms, crops, etc., to maintain the mills in full operation. For the second period of the year most of the re-rollers have accepted heavy bookings and, subject to the provision of railway facilities, there is no reason to apprehend any lack of material.

Production of steel plates has been substantially increased, but the demand seems to be as inisistent as ever. Apart from shipbuilders' specifications, which are accorded special priority, there is a big demand for tank and boiler plates, and locomotive and wagon builders are using bigger tonnages than ever before. Hence orders need to be placed from three to six months in advance of required delivery dates. For light and medium sections, the pressure is less severe, and interest in heavy sizes is waning.

Expectations of a new spate of orders for black and painted sheets for the second period have not been falsified. Interest is chiefly focussed on the lighter gauges, which are wanted in large quantities for military purposes. Mild-steel bars of all sizes are in steady request, collieries are seeking good tonnages of arches, roofing bars, props and rails, railway material continues in brisk demand, and wire drawers are working to capacity.

NON-FERROUS METALS

The U.S. War Production Board has intimated that, in view of the declining domestic copper production, it may be necessary to draw upon the stocks held by the Government. This indicates that American consumption of copper is again on the increase. It is probable that the increase is to some extent due to the fact that shell cases are once more being made of brass, in place of the steel which had hitherto been used because of the need to economise in copper. The need for increased production has been stressed, and output during the year, if there are no labour troubles, should be considerable.

Tin supplies are reasonably satisfactory. Output in Nigeria and other areas available to us is steadily increasing, although the total is not large, and as it is not likely that the Far Eastern deposits will be regained for a considerable time, the position will depend on these workings even after the war.

Conditions in the market for lead have not changed much recently. In the post-war housing schemes, lead and other non-ferrous metals will be utilised extensively and reserve stocks and scrap should serve in good stead.

MR. D. Y. B. TANQUERAY, a director of Baker Perkins, Limited, engineers and iron and steel and brass founders, of Peterborough, has died at the age of 47.

MR. T. HERBERT CARTER, senior partner of Henry Carter & Sons, brass and iron founders, Cyclops Foundry, Kirbymoorside, Yorkshire, has died at the age of 76. He was the third generation in the business, which now falls to his three sons, who have been associated with him for some years.

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